AN INTEGRATED WATERSHED DEVELOPMENT PLAN FOR KUNDAPURA TALUK, UDUPI DISTRICT, KARNATAKA, INDIA USINIG RS AND GIS TECHNIQUES

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1. Introduction

Water is the life of us. Our future is water. We cannot survive without it, and there is no alternative. The global shortage of available water supply is an issue that presents a dangerous problem for our future. Water covers 71% of the surface of the Earth and is important to all known life forms. The Earth is a watery place. But just how much water exists on, in, and above our planet? About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. Water also exists in the air as water vapor, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers, (https://www.usgs.gov/special-topic/water-science)-Only 2.5% of the Earth's water is freshwater and 98.8% of that water is in ice and groundwater. Less than 0.3% of all freshwater is present in streams, ponds and the atmosphere, and an even smaller amount of freshwater from the Earth (0.003%) is distributed within human bodies and manufactured products. The level at which we currently spend water in tandem with increasing populations leaves a future full of questions and requires action at the moment. If global water issues are not addressed today, there will be considerably limited future sustainability.

The thirst of water for India's rapid development is growing day by day. In spite of adequate average rainfall in India, there is large area under the less water conditions/drought prone. There is lot of places, where the quality of groundwater is not good. Another issue lies in interstate distribution of rivers. Water supply of the 90% of India's territory is served by inter-state rivers. It has created growing number of conflicts across the states and to the whole country on water sharing issues (WWW. Water scarcity and India for the Changing Planet).
In this context in the present study an attempt has been made to understand the water resources of Kundapura taluk of Udupi based on geospatial techniques. Kundapura is located in Udupi district of Karnataka.

The ground water-level in the taluk has declined over the years. Though some areas have bore wells but the water sources in these bore wells are said to be contaminated. Nearly 24 villages in Kundapur and Byndoor are crippled with drinking water shortage, with tanker water supply the last resort being opted by the local governing bodies. Areas like Hemmadi, Beejur, Nada, Shankarnarayana, Trasi, Kalavara, Basrur, Belve, Tallur, Vandse, Yedthare, Kergal, Kirimajeshwara, Shiroor, Kavradi, Kumbhashi, Byndoor, Paduvari, Koteshwara, Kedur, Gujjadi, Karkunje, Hakladi, Amparu, Alur, Uppinakudru, Chitthoor, Mudagopadi are affected by the water scarcity to the hilt.

Geospatial techniques mainly comprise of Remote Sensing, GPS, Geodesy, Photogrammetry, GIS and computer applications. Remote sensing is a powerful technology, which can be used effectively to observe the Earth's surface at a distance and to interpret the images or numerical values obtained in order to acquire meaningful information of particular objects on earth. The result is usually stored as image data (Aerial photographs are also considered as image data). The characteristics measured by a sensor are the electromagnetic energy reflected or emitted by the Earth's surface. This energy relates to some specific parts of the electromagnetic spectrum usually visible light, but it may also be infrared light or radio waves. GIS provides a common framework – spatial location – for watershed management data obtained from a variety of sources. Because watershed data and watershed biophysical processes have spatial dimensions, GIS is a powerful tool and can be effectively used for understanding these processes and for managing potential impacts of human activities. The modeling and visualization capabilities of modern GIS, coupled with the explosive growth of the Internet and the World Wide Web, offer fundamentally new tools to understand the processes and dynamics that shape the physical, biological and chemical environment of watersheds. From its modest beginning with surface water, inventory this technology has progressed to more complex management tasks such as irrigation system performance evaluation and diagnostics, country-wide drought monitoring, rainfall estimation, snowmelt runoff forecasts, reservoir sedimentation and watershed treatment, flood mapping and management and environmental impact assessment.

2. Study area:

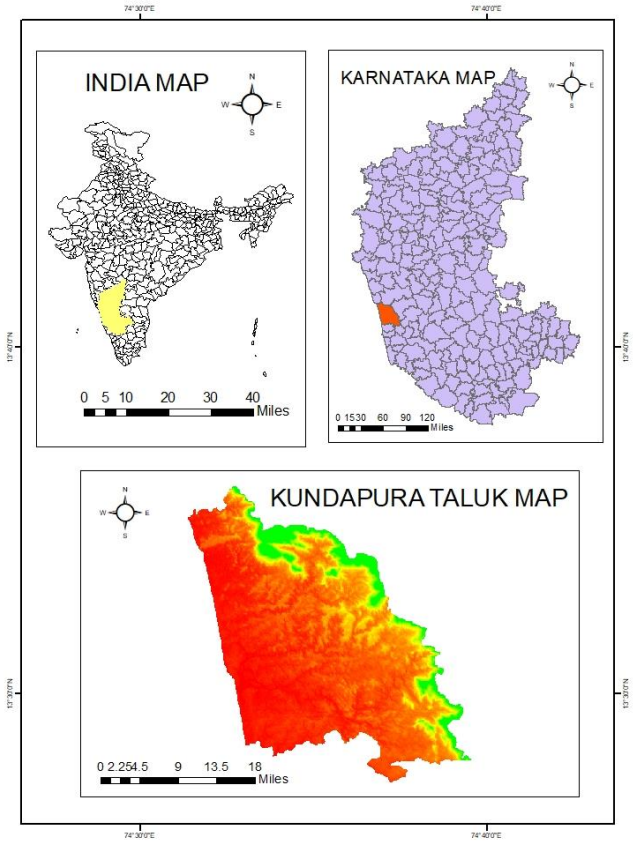

Fig 1.1: Study area

Kundapura taluk is located in Udupi district of Karnataka. Kundapura is the northern taluk of Udupi district and has a geographical area of 1569 sq. km. It lies between 74°34′40.0″E to 75°4′57.35″E longitudes and 13°28′40.82″N to 13°59′33.26″N latitude. This taluk has many rivers and experiences significant precipitation. The main streams are Venkatapura river, Kollur river (tributaries of Chakra and Souparnika), Haladi-Varahi river, Sita river, Yadamavina Hole and Uppunda hole. Kundapura is encircled by Udupi Taluk towards South, Bhatkal Taluk towards North, Hosanagara Taluk towards East, Karkal Taluk towards South. Kundapura municipality is supplying enough drinking water to people living in 101 villages covered by 56gram -panchayats of the taluk has become a mammoth ordeal for the local bodies. One or more areas in each of these villages have been left thirsty because of water scarcity and official apathy. The problem of sea water getting mixed with underground water table has become acute in many of the gram panchayats like Gangolli and Tallur, which are located on the seashore. Villages like Hattiangadi, Chittur, Alur, Karkunje,

Kedoor and others, which are situated some distance away from the sea, have another problem on hand. There, drinking water sources have dried up as water table has depleted by a great extent. Yadamoge is a village nested at the foot of the Western Ghats. On one side of the village, greenery abounds. But inside the village, land that has turned dry, plants and trees which have withered due to strong sunshine, dried wells and bore wells have made the people to hanker for water that has vanished.

3. Objectives:

The main aim of the watershed management is to establish the sustainable management of natural resources to improve the socioeconomic status of the population, which can be accomplished by the following objectives:

- Explore the potential of sustainable watershed management studies using RS and GIS techniques
- Judicious use of all the natural resources i.e., land, water, vegetation of the area
- Identify the groundwater potential zones and problematic areas for groundwater harvesting
- Generation of thematic maps related to soil, water and vegetation
- Improvement and restoration of soil quality, soil erosion and thus, raising productivity rates.
- Mapping and Monitoring the saline water intrusion problems
- Supply and securing of clean and sufficient drinking water for the population.
- Improvement of infrastructure for storage, transport and agricultural marketing.
- Manage the watershed for beneficial developmental activities like domestic water supply, irrigation, hydropower generation etc.
- Minimize the risks of floods, droughts and landslides.
- Develop rural areas in the region with clear plans for improving the economy of the regions.

4. Materials and Methodology:

4.1. Primary data:

- Survey of India Topographical maps on 1:50,000 scale
- Satellite images of IRS series, Earth explorer (ASTER, SRTM, LANDSAT 8 OLI)
- Google Images
- Global Positioning System (GPS) to collect more GCPs (ground control points).

4.2. Secondary data:

- Meteorological data from Indian Meteorological Department (IMD) and District Statistical Department, Mangalore.
- Water level fluctuation and yield data from Mines & Geology Department, Udupi.
- Geological and Soil maps from Karnataka State Remote Sensing Application Center, Bangalore
- Necessary published maps, reports and literatures.

Methodology:

Survey of India topographical maps on 1: 50,000 scales have been used to generate the base map. Drainage map has been generated based on the topographical map. Published maps, reports have been used in addition to the ground truth data. The IRS and Landsat satellite images have been subjected to various image processing techniques like contrast stretching, band ratioing, edge enhancement, Principal component analysis and density slicing. Supervised and unsupervised classification of the satellite data have been carried out to generate landuse/land cover maps upto level 3 classes. From the SRTM and ASTER data Digital Elevation Model (DEM) of the study are has been generated. Later from the DEM, slope, aspect, TIN and shaded relief maps have been generated to get the information on water resources and geomorphology. Different thematic maps such as geology, geomorphology, drainage density, DEM, slope, aspect, soil, land use / land cover have been generated based on remotely sensed data through visual and digital analysis. Ground truth data such as bore well stock, yield, depth, water table fluctuation, etc. have been collected by extensive field work. The Information derived on the lithology of the area and geomorphic and structural features in conjunction with recharge condition and precipitation have been used to infer groundwater potential of each lithological unit, soil resource maps have been prepared by delineating subdivisions within each geomorphic unit based on the status of

erosion, land use / land cover, and image elements, including color, texture, form, pattern, and association. The soil composition of each geomorphic unit has been described by the study and classification of soil profiles in the field on the basis of morphological characteristics and chemical analysis data (USDA, 1998).

An effort has been made to establish an evaporation, evapotranspiration and runoff estimation method in order to optimize the use of water, less water consuming plants/ crops have been suggested

5. Organization of chapters:

The thesis has been organised in 8 chapters. Chapter 1 covers introduction about the study area i.e., Kundapura and literature reviews on watershed management. Chapter 2 covers geology, geomorphology of Kundapura taluk. Chapter 3 is a study on physico-chemical analysis of groundwater of Kundapura taluk. Chapter 4 covers soil erosion and their prioritization in watersheds. Chapter 5 focuses on saltwater intrusion problems of Kundapura taluk. Chapter 6 is on identification of groundwater prospect zones and suitable sites for artificial recharge. Chapter 7 deals with suggestions and action plans on sustainable watershed management and Chapter 8 is on Summary and Conclusion.

Chapter 1:

This chapter gives a complete introduction about watershed management. How much water is important, their losses, their conservation and methods using RS and GIS powerful tools, which can be effectively used to understand the problems of the study area. the chapter also gives introduction about Kundapura taluk, water related problems, geology, soil, climate, drainage, main objectives, materials and methods and literature reviews. the research work carried out is represented in the in the form of flow chart (Fig.1.2).

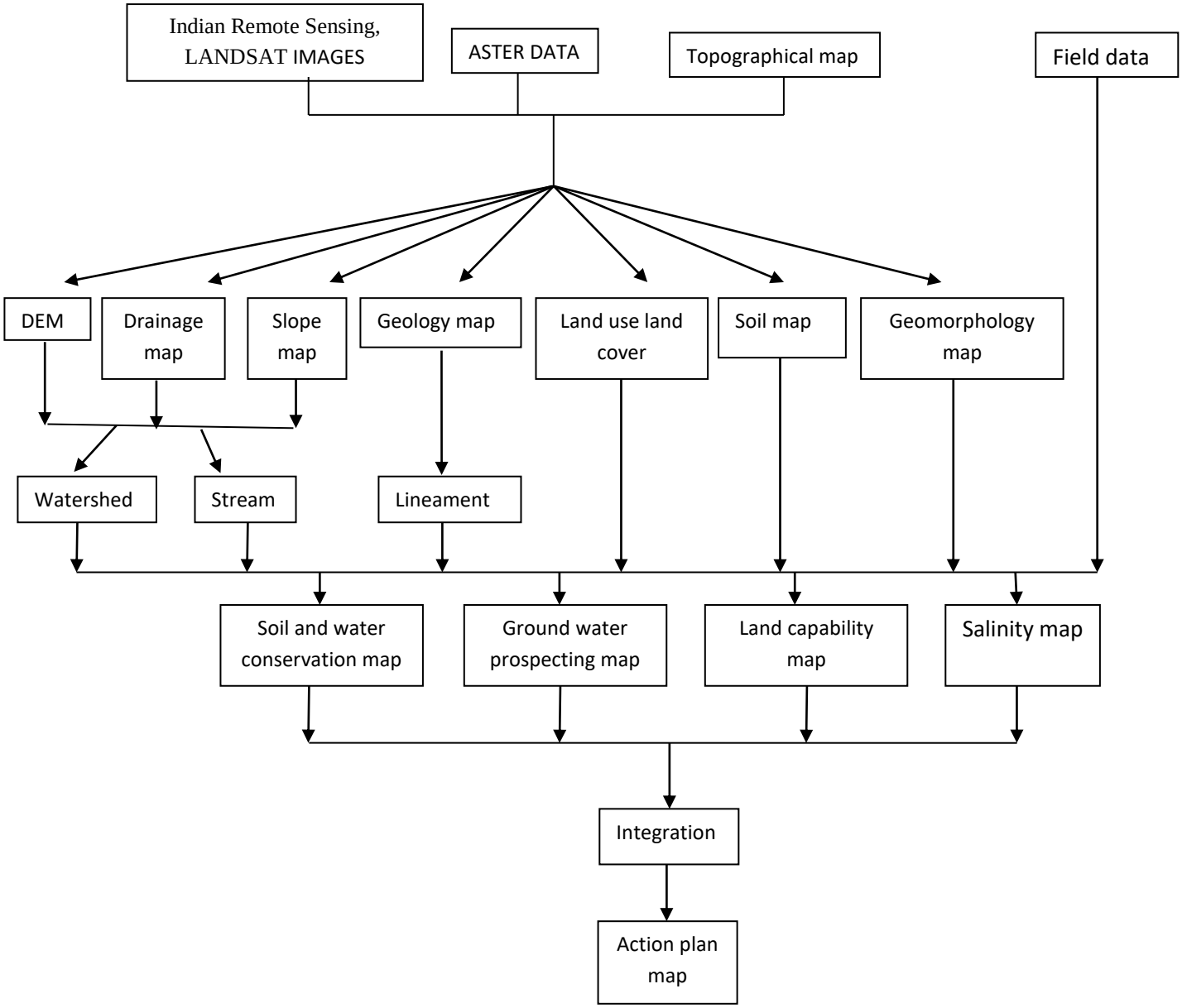

Fig 1.2: Schematic representation of the study

Chapter 2

This chapter has been focused on morphometric analysis and morphology of Kundapura taluk. Strahler (1964) method has been adopted for morphometric analysis of Kudapura Geospatial techniques such as remote sensing and GIS, have been used for watershed management and drainage network analysis. ASTER data has been used for morphometric evaluation of groundwater and analysis of multiple morphometric parameters. Techniques developed by Horton and Strahler have been used to analyze and assess the morphometric parameters of Kundapura taluk. Further the study area has been divided into four sub-watersheds, SW-1, SW-2, SW-3 and SW-4. These sub-watersheds have been

demarcated based on the development and management schemes to sustainably preserve natural resources with instant impact, eventually resulting in soil and water conservation, including drainage density, slope, water output ability, groundwater potential, soil, wasteland, irrigated region and forest cover. Hypsometric curves of the study area are obtained by using the hypsometric tool which is available as an ArcGIS extension. Hypsometric curves and integrals have been interpreted in terms of degree of basin dissection and relative landform age. Convex-up curves with high integrals are typical for young, dissected (disequilibrium stage) landscapes; smooth, S-shaped curves crossing the centre of the diagram characterize mature (equilibrium stage) landscapes; and concave up with low integrals typify old and deeply dissected landscapes (Strahler, 1952).

Chapter 3:

In this chapter an attempt has been made to determine various physico-chemical parameters and water quality index of Kundapura taluk using nine parameters, which are a pH, Electrical Conductivity (E.C), Total Dissolved Solids (T.D.S), Total Hardness (T.H), Alkalinity, acidity, Chlorides (Cl), Dissolved Oxygen (D.O), and Chemical Oxygen Demand (C.O.D), measured at 40 places. Weighted Arithmetic Water Quality index (WAWQI) method has been used for calculation of water quality index. The post summer values of pH, at places like MITK (Moodlakatte Institute of Technology), Margoli and Kodi are having high pH and Kumbashi and Amavasyebailu having low pH. Places like Margoli, Beejadi, Senapura, Kollur and Kodi shows higher E.C and Amparu shows lower E.C. Higher acidic acidic water. Alkaline water balances the body pH and higher alkalinityis noticed in Kodi, Beejadi & Marvanthe and lower alkalinity in Yedthare, Mullikatte and Trasi. Majority of the water samples show more COD content; hence it decreases the amount of D.O content in water. Pre-summer and post-summer values show distinction in numerous physico-chemical parameters. During the post summer water level decreases mechanically and added to this over exploitation of water for drinking and irrigation has resulted a cone of depression and this has increased the saltwater intrusion problems in coastal aquifers of Kundapura taluk. Due to this water lose its quality, hence, pre-treatment is an additional necessity in post-summer. Results of this analysis have been used to the extent possible to forecast the hydrologic responses of the aquifer system to future changes due to anthropogenic and natural stresses.

Chapter 4:

This chapter explores the use of RUSLE model together with Remote Sensing and GIS techniques to assess and quantify the soil loss. The area is chosen because of the major problems observed in the watershed include improper management of agricultural lands, soil erosion, reduction in yields of crops, ground water depletion, degradation of forest/ tree plantation areas, non-availability of drinking water particularly in summer months and poor socio-economic condition of the farmers. The present study effectively proved the importance and role of remote sensing and GIS to understand the geological processes and the RULSE method/model can be effectively used for erosion mapping. The work has been carried out using freely available data which expands the usability and accessibility of the work produced, ensuring the continuity for further comparative studies. Similar studies are also essential for the adjacent areas in the Konkan belt to compare and improvise better planning measures by town planning departments. This study has helped to understand and quantify soil erodibility rate.

Chapter 5:

In this chapter a study on intrusion of saltwater into freshwater aquifers from the sea has been carried out to understand the drinking water quality. The main aim of the study is to map susceptibility in the coastal zone to groundwater salinity and to delineate salinity in groundwater using remote sensing by mapping the occurrence of surface salinity. The coast of Kundapura experiences more saline intrusion in post-summer than in pre-summer. The GALDIT model weightage-driven technique, has been used based on hydrogeological parameters to determine the vulnerability of coastal aquifers. It is a method for determining vulnerability to aquifer contamination and rating for vulnerability index estimation, which is measured in a well-defined manner from hydro-geological, morphological and other aquifer characteristics. The implementation of an index has the benefit that subjectivity in the rating system is removed or reduced in theory (Chachadi and Lobo-Ferreira, 2001). Each of the six parameters, according to the GALDIT model, has a predetermined relative fixed weight that reflects its relative importance of vulnerability. The following term obtains the marine invasion aquifer susceptibility index.

GALDIT=1*G+3*A+4*L+2*D+1*I+2*T

The process by which salts accrue on the soil surface and in the root zone leads to soil salinization. It effects on the growth of many crops, and the physical and chemical properties of soil, especially in arid and semiarid regions (Rachid et al.,2014). It may arise naturally or as a consequence of bad management of human practices (Jingwei et al., 2008). Soil salinization is a process of enriching the soil with soluble salts to deleterious levels at or near the soil surface (Metternicht et al., 2008), resulting in modification of biochemical features of soil. Saline intrusion occurs when salts are dissolved in water to accumulate in the soil at a level that affects agricultural production, environment, and economics. Initially, in the first phase, salinity affects the metabolism of soil organisms and reduces the productivity of land. In the next phase, it destroys all the plants and other organisms living in the soil. Saline intrusion is one of the influential factors leading to land degradation, and triggering a significant threat on the sustainable growth and economic benefits. In this research, Operational Land Imager (OLI) sensor, on board the Landsat 8 satellite, acquired on February 22, 2019 from USGS Earth Explorer site earthexplorer.usgs.gov, with (30m) spatial resolution has been analysed. The images utilized in this research have been systematically corrected after downloading. The images have been geo-rectified to a Universal Transverse Mercator (UTM) coordinate system, using World Geodetic System (WGS) 1984 datum, Zone 43N. The most compatible dates have been selected in harmony to the dates of field work to avoid any problems including seasonal changes. The desired date in April/May denotes to scarcity of clouds with higher averages of salt accumulation and surface reflectance. The image analysis has been processed using Arc GIS 10.5.1.

Chapter 6:

In this chapter the investigation has been carried out to delineate the areas with promising groundwater potential zones and flood zones in IRB and the composite map of groundwater potential zones. In the present study, the choice among a set of zones for development of groundwater is based upon multi-criteria evaluation technique, which gives linear combination of probability weights for different themes considered for the study. Various thematic maps are reclassified on the basis of weightage assigned and brought into the “Raster Calculator” function of 'Spatial Analyst' tool of Arc GIS software. The 'Spatial Analyst' tool consisting of mathematical and Boolean operators has been used for integration. The weightages for different layers have been assigned by considering the research work carried out by Krishnamurthy et al. (1996). Vidhya Lakshmi et al., (2018) and Preeja et al.,

(2011). A “Simple Arithmetical Model” in Arc GIS software has been adopted to integrate various thematic maps by averaging the weightages, classifying potential zones based on decision rules and groundwater potential zone map has been generated.

Chapter 7:

In this chapter the investigation has been carried out Using 14 distinct important hydrologic parameters, the ArcGIS enabled SWAT (Arc-SWAT) model was utilized to simulate stream flow from the SW-2 basin. Within the SWAT-CUP modeling, uncertainty and risk assessments were performed using the SUFI-2 method. The SWAT-CUP semi-automated stochastic model enhanced SWAT predictions of surface runoff with a precise research permissible range of important hydrologic parameters and higher statistical evaluation parameters indicating more dependability of simulated findings.

Chapter 8

Overall Summary and Conclusions have been provided in this chapter. The watershed perspective is the best framework for integrating social, ecological, and economic aspects of water and water-related management issues. The watershed development plan can be implemented in the watershed area, to increase the groundwater level (by recharging the aquifers), crop yield and production in the watersheds of Kundapura. A wise use of the resources (soil, vegetation and water) will enable sustainable production. By judicious use of groundwater, salt water intrusion problems can be solved. By afforestation program green cover of the watershed can be increased and it will reduce the soil erosion. The sustainable development of the natural resources will help to improve the Socio-economic condition of the farmers. Components of the landscape are connected, and that surface water, ground water, and drinking water are directly related resources that must be managed together rather than separately. Soil erosion and preventive measures will help in resolving agricultural issues and will help the farmers to retain the fertility of the top soil. Identification of saline water intrusion zones will help to tackle the drinking water crisis/problem in a better way.

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Publications:

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3. Poojashree. B. P, H. Gangadhara Bhat and Bhavya P, 2021. "Saltwater Intrusion Study of Kundapura Taluk Using RS and GIS by GALDIT Method Udupi District, Karnataka, India". e-Proceedings, "Sustainable Water Resources Development and Management", Proceedings of Online International Conference on SWARDAM–2021. ISBN: 978-81-952843-9-9 (eBook).
4. Bhavya, P, H. Gangadhara, Bhat and Poojashree, B .P, 2021. Morphotectonic analysis for watersheds of Shikaripura taluk, Shivamogga district, Karnataka: using RS and GIS. International Journal of Development Research Vol. 11, Issue, 02, pp.44489-44494, February, 2021.

PRESENTATIONS IN National and INTERNATIONAL CONFERENCES (the presenter is underlined)

1. **Poojashree. B. P**, H. Gangadhara Bhat and Bhavya P, 2021. Presented a paper on International online Conference on Proceedings of "Sustainable Water Resources Development and Management", SWARDAM-2021, about "Saltwater Intrusion Study of Kundapura Taluk Using RS and GIS by GALDIT Method Udupi District, Karnataka, India".
2. **Bhavya P**, H. Gangadhara Bhat and Poojashree. B. P, 2021. Presented a paper on International online Conference on Proceedings of "Sustainable Water Resources Development and Management", SWARDAM-2021, about "Sustainable Agroforestry System for Conservation of water Resources By using Remote Sensing and GIS for Shikaripura Taluk".

3. **Poojashree B.P** and Bhavya P, 2017 Presented a paper in National Conference on WATER CONSERVATION AND MANAGEMENT IN THE COASTAL REGIONS-2017 at Vivekananda college of Engineering and Technology, Puttur, Karnataka. about Determination of Infiltration Rate of Soils using Double Ring Infiltrometer.